DOCUMENT RESUME

ED 428 709 IR 019 370

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TITLE Hypermedia as a Cognitive Tool.
PUB DATE 1998-06-00
NOTE 8p.; In: ED-MEDIA/ED-TELECOM 98 World Conference on Educational Multimedia and Hypermedia & World Conference on Educational Telecommunications. Proceedings (10th, Freiburg, Germany, June 20-25, 1998); see IR 019 307. Figure may not reproduce clearly.
PUB TYPE Reports - Research (143) -- Speeches/Meeting Papers (150)
EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Authoring Aids (Programming); College Students; Computer Uses in Education; *Concept Mapping; Content Analysis; Design Preferences; Educational Practices; Educational Technology; Foreign Countries; Guidelines; Higher Education; *Hypermedia; Instructional Design; Instructional Effectiveness; *Knowledge Representation; *Material Development; *Screen Design (Computers); *Student Developed Materials
IDENTIFIERS Authorware; *Document Structure; Links (Indexing)

ABSTRACT

This paper reports on a study that observed students creating structured hypertext documents, and how they try to convey structural information, in order to formulate tentative guidelines/principles for the design of concept mapping tools or hypertext systems with an emphasis on the representation of structural knowledge, and to formulated guidelines or principles for educational practice. Student use of hypertext and DarkStar, the hypertext authoring system used in the study, are described; concept mapping, structural information, and hypertext, and their effects on education, are discussed. A sample of 143 student-created documents were analyzed according to the structure of the whole document as it appeared on the Overview Map, as well as layout and screen design. Results indicated that: students predominantly used a hierarchical form of structuring information; students predominantly linked the same term occurring on two nodes of their document; students are acquainted with basic principles of screen design and use them to structure their documents; chunking and queuing information are popular with students; and pictures and graphics were rarely used. A figure illustrates the overview editor. Two tables present data on the distribution of hierarchical versus non-hierarchical links and organization of information on the screen. Contains 14 references. (DLS)

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Hypermedia as a Cognitive Tool

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ED 428 709

Abstract: Hypertext and Hypermedia systems can be used in many different ways, among others as "cognitive tools". Such hypermedia systems are supposed to help learners structure their thought processes and gain a deeper understanding of the subject material. The following text describes the way how students at the University of Technology Vienna used a concept mapping tool based on a hypermedia system. The results show that most of the students use such tools in a rather conservative manner. Nevertheless, there is a minority which tries out innovative features in a very creative way.

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1. Introduction

Hypertext and hypermedia systems can be used in educational environments in a number of different ways. One possibility how such systems can be employed is the support of students creating externalized versions of their own knowledge structures, especially in the form of graphs. The technique of motivating students to use elaborate learning strategies by drawing spatial representations of their knowledge structures is an old one and has been developed for paper and pencil. Several different names have been used for such techniques, e.g. concept maps, cognitive maps or semantic maps. In the following paper, the term concept maps [Novak & Gowin 1984] will be used. Because of its flexibility and the possibility to re-edit existing concept maps, the computer in general and hypertext systems specifically seem to be especially appropriate media for this methodology.

So far, the majority of investigations of the usage of computer based concept mapping systems have concentrated on the question whether concept mapping is a superior form of learning compared to more traditional methods. Generally, the results of these investigations have been promising although some specific problems can be observed. The aim of the study described in the following paper is different although it is based on the notion that computer based concept mapping tools can be used successfully in an educational context. Initial motivation for the study was our observation that students who develop hypertext documents seldom use novel or innovative structural features of hypertext systems, and if they use them they do it in an unpredictable manner. It was, therefore, the aim of our project to investigate how students develop hypertext documents and especially how they try to structure the information in their documents and which structure-generating features of the system are more attractive than others.

2. The System DarkStar

The topic of our study is based on the experience gained during a project concerning hypermedia and learning which was carried out at our department between 1992 and 1994. Inspired by George Landow [Landow 1992] we asked students to write their own hypertext documents as assignments in seminars. We soon realized that students had serious conceptual problems with this task. The most important of these problems was that they had difficulties to translate the linear texts which they were supposed to read during the seminars into non-linear hypertext. This circumstantial evidence motivated us to develop the system DarkStar which is based on HyperCard and which was supposed to help students create more innovative hypertext documents. Innovative in this context means that students were to a certain extent constrained to use novel features of the hypertext concept like non-

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linear links between pieces of text, pop-up fields with examples or explanations, or graphics and animation. All these features are novel in the sense that it is either not possible at all to use them in books or at least very difficult. We assume that hypertext enables students to get insights into the material they study which they cannot get by reading and writing linear text. In this sense, hypertext systems can serve as cognitive tools [see Kommers, Jonassen & Mayes 1992]. As the students seemed to have the most difficulties with the concept of hypertextual structure, the system DarkStar contained many elements to make structuring easier. One of the most popular of these features was the so-called Overview Editor [Fig. 1], a tool which resembles other electronic concept mapping tools to a large extent. The Overview Editor allowed students to create, delete and name links and nodes and to position links and nodes in the two-dimensional space offered by the computer screen.

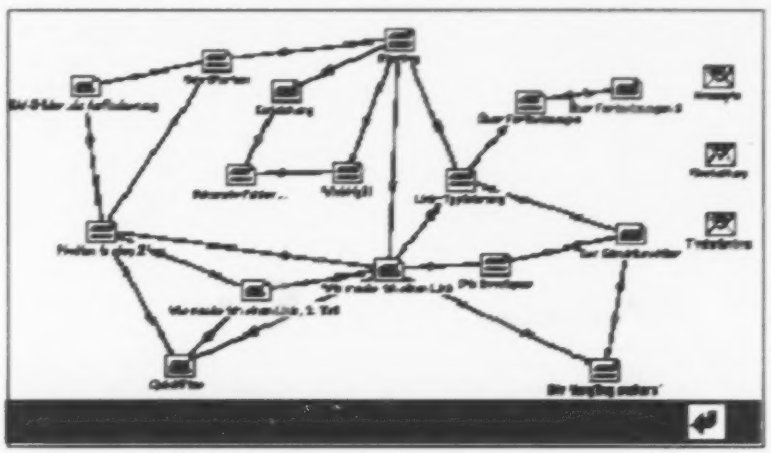

Figure 1: The Overview Editor

DarkStar was developed iteratively. It was evaluated continually to assess whether it really supported students to fulfill their task. There is some promising evidence that it is possible to improve the quality of the students' documents by offering them a hypertext authoring tool which is specifically adapted to their needs [Pohl, Purgathofer & Prenner 1995].

3. Concept Mapping, Structural Information and Hypertext

According to [Novak & Gowin 1984] concept maps are graphical representations of concepts and their relationships. The concepts represent a small number of key ideas. The formulation of such key ideas are crucial for every learning task. Based on their practical experience, Novak and Gowin suggest several different ways of applying concept maps, among them: exploration of what the learners already know, extracting meaning from textbooks, planning a paper or exposition, etc. Our approach to concept maps is slightly different to the one of Novak & Gowin. On the one hand, we use concept maps in our teaching practice only in combination with "normal" hypertext systems. Structural information is not only conveyed through the concept map but also through the topological organisation of text on the screen and the use of graphical material, and it can be assumed that there is an interaction between these two components. On the other hand, we try to motivate students to organise information in novel ways, among others as non-hierarchical structures. This contradicts Novak and Gowin's ideas to a certain extent as they demand that concept maps have to be hierarchical.

There is some evidence that the use of concept maps in learning environments can have beneficial effects. [Kozma 1992], [Kommers & de de Vries 1992] and [Fisher 1992] who used computer based

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concept mapping tools report positive results. [Reader and Hammond 1994] argue that concept mapping is a more time consuming method than traditional forms of learning. Thus, students are motivated to spend more time going through the material and analysing it. This leads to a better performance of those students developing concept maps. [Jonassen and Reeves 1996] also give an overview over research supporting the use of concept maps. They point out that concept maps are a powerful tool to analyse the learning process and students' changing knowledge representations. The studies quoted above also discuss important factors which influence the usage and design of computer based concept mapping tools. Concept mapping is more beneficial with advanced students than with beginners [Kozma 1992]. The introduction of concept mapping tools or more generally hypertext necessitates a modified curriculum and a change of the criteria for testing students' achievements [Kommers & de Vries 1992], [Jonassen & Reeves 1996]. Students have problems with several novel features of concept mapping tools [Fisher 1992].

In general, it can be said that the efficiency of concept mapping as a methodology of learning is to a certain extent supported by empirical evidence. Concept mapping and hypertext as a theoretical concept apparently share a number of traits. Therefore, computer based concept mapping tools are often either integrated into hypertext systems or used in combination with hypertext.

4. The Study - Aims and Methodology

The aim of the study described below is to observe how students using a hypertext system develop their own documents, and especially how they try to convey structural information. We think that structural information can be expressed in at least two ways: in a concept map or content overview and through the use of topological cues on the other pages of the hypertext document. In the tradition of [Novak & Gowin 1984] our students were encouraged to develop documents with little text and much structural information. The task of developing hypertext documents is part of the normal work routine of students at our department. This implies that task and setting were realistic and relevant as far as students' experiences are concerned.

The practical aim of our investigation is, first, to formulate tentative guidelines or principles for the design of concept mapping tools or hypertext systems with an emphasis on the representation of structural knowledge. In this context, it is necessary to find out which features are not accepted by the users and to formulate ideas how to enhance the usabiltiy and affordance (Norman 1988) of those features which are accepted. Second, we want to formulate tentative guidelines or principles for the educational practice. We posit that knowledge about how students use hypertext systems can help teachers to advise students more systematically.

For our investigation, we used a sample of 143 documents which are a representative cross-section of all the documents created by students at our departments. All the documents were developed with the system DarkStar. To analyse the documents we used a collection of categories which were partly derived from the relevant literature and partly from our practical experience. These categories sometimes ask for subjective judgements. By defining the categories carefully, we tried to minimize any possible subjective bias. The method of analysis is descriptive. It can be argued that such methods form a valuable contribution to educational research [Knupfer & McLellan 1996].

We used two different sets of categories. One set was mainly concerned with the structure of the whole document as it appeared on the Overview Map. The other set dealt with layout and screen design. The most important question the first set of categories tried to answer was whether students adopted traditional hierarchical forms of structuring information or not. Link types are treated insofar as they can clarify this issue.

The second set of categories examined the question whether students used layout, screen design or graphical elements to convey a sense of structure. Typographic and layout features which play an important role in this context are highlighting [Mayhew 1992], grouping [Mayhew 1992], [Tullis 1991], and the distribution of white and black space on the screen [Watzmann 1993]. Highlighting is a possibility to point out important concepts in the text to the reader. Nevertheless, it should be used sparingly. Grouping is to a certain extent based on the Gestalt laws of proximity. It is a powerful tool

to show which elements belong together and which do not. Factors which influence grouping are proximity, colour, graphical boundaries and highlighting. All these factors should make semantic relationships between the objects on the screen visible [Tullis 1991]. The distribution of white and black space on the screen, which is to a certain extent related to grouping, provides a clear path through the material and gives a conceptual framework of the text [Watzmann 1993]. In more sophisticated forms of page design, information is presented in chunks. These chunks are organised according to the semantic meaning of the text. This results in a complex pattern of black and white on the screen which differs from the traditional "grey" page of a book.

5. Results

5.1. Hierarchical vs. Non-hierarchical Structure

As already mentioned, students predominantly used a hierarchical form of structuring information [Tab 1].

	absolute numbe	%
hierarchical links	4240	85,20%
non-hierarchical links	584	11,70%
links to other document	153	3,10%
•	4977	100,00%

Table 1: Distribution of hierarchical vs. non-hierarchical links

As we can see, hierarchical links are by far the most frequent form of link type. The category "links to other documents" represents links which students made to other students' hypertext documents. As students who attended the same seminar worked in parallel at their documents this was apparently a problem. Only very few students used this possibility.

There are only three documents with no hierarchical links at all. In contrast to that, there are 83 documents with no non-hierarchical links at all. The document with the maximum number of hierarchical links contains 130 links of that type. The document with the maximum number of non-hierarchical links contains 37 links of that type. There are also several other documents with a considerable amount of non-hierarchical links. This indicates that many students did not realize the possibilities offered by non-hierarchical links. On the other hand, there are several students who realized these possibilities and used this feature extensively.

5.2. Link Types

The term link type in this context is perhaps misleading as it is used in the literature to characterize link types belonging to a complete system of link classification. In contrast to that, the term link type here refers to a few characteristic linking methods which students used to express their ideas about structure. This concept of link types was not developed theoretically but rather deducted from our practical experience with students' hypertext documents.

Link between the same term on two nodes: Students very often use this method of linking two nodes. They happen to notice that one and the same term occurs on two nodes in their document. Therefore, they create a link between those two nodes. The interpretation of this process is ambiguous. On the one hand, it can be argued that this form of linking does not require elaborate thought process and is rather mechanical. We found several examples for fairly useless or even confusing links of that type in students' documents. On the other hand, it sounds plausible that for the reader of a hypertext document it is easier to grasp the structure when the same terms are used on both nodes he has visited. For us it is, therefore an open question whether to advise students to use this kind of link.

3804 (76,4%) out of 4977 links are links between the same term on two nodes.

Examples: Students fairly often use links to refer to examples which illustrate an idea brought up in the text. 1324 (26,6%) out of 4977 links are of that type. Only 26 out of 143 documents do not contain any examples. Students differ considerably in the amount of examples they include in their documents. One document even contained 46 examples.

Explanations: Students also fairly often use links to refer to explanations of terms used in their document. 1890 (37,9%) out of 4977 links are of that type. Only 9 out of 143 documents do not contain any explanatory links. The maximum of explanatory links in a document is 71.

Example links and explanatory links are rather similar in at least two respects. They were categorized as hierarchical links in the category system we used. In contrast to that, examples and explanations are usually seen as a form of digression in a linear text. In this sense, examples and explanations can be seen as a feature which transcends the distinction between hierarchical and non-hierarchical structure. The second similarity is the fact that in both cases some students use this feature quite heavily whereas others do not use it at all. This probably indicates that some students did not realize that they had this possibility whereas others who were aware of it used it quite intensively.

5.3. Typography

126 out of 143 documents use an acceptable font size for text (12 point). 114 documents use bold for highlighting and only 18 italics. All documents either used indentation or empty lines as methods of structuring their text. In general, this shows that students are acquainted with basic principles of screen design and use them to structure their documents.

5.4. Grid

The term "grid" refers to the categories introduced by [Watzmann 1993]. She tries to formulate criteria for the quality of screen design. Good screen design, according to her opinion, is highly structured and uses a range of different topological or graphical cues. [Tab. 2] shows to what extent the students at our department used methods of structuring text and pictures on the screen.

	yes (no of documents)	no (no of documents)	partly (no of documents)
gray page	25	118	0
chunking	120	2	21
queuing	100	43	0
mixing modes	38	105	0

Table 2: Organisation of information on the screen

The term "gray page" describes a screen which resembles a traditional book with no organisation of the information at all. Chunking means that information is divided into small, meaningful pieces of text. Queuing leads to an even more structured screen. Information is arranged topologically, so that the position of pieces of text conveys meaning. Mixing modes refers to a screen design which includes different modes of expression (text, graphics, pictures, formulas etc.).

Chunking and queuing seem to be very popular with our students. This shows that they have realized that a computer screen offers possibilites which do not exist in a book. Nevertheless, the students we observed in our study did not use pictures, graphics or other modes very often [see 5.5.].

5.5. Use of Pictures and Graphics

Only 41 (29%) documents out of 143 use graphics or pictures. Whereas the students we observed showed a certain ability to develop a satisfying layout they are still not very creative as far as use of other modes of representation are concerned.

6. Conclusion

The aim of the study described in this paper was the observation of students creating structured hypertext documents. The students, in general, had difficulties with novel ways of structuring information, especially with non-hierarchical structure. New possibilities which are offered by electronic text are more easily accepted if they resemble traditional linear text to a certain extent as, for example, links to explanations and examples. Features of structured hypertext which are attractive or at least potentially attractive seem to be characterized by the fact that many students who use them do that quite intensively. This indicates that those students who did realize the advantage of novel structuring possibilities try to apply them fairly often. The study described above still does not give a very comprehensive picture of the activities students are engaged in when they structure their hypertext documents. It would be interesting to assess whether the contents of the material the students have to learn has any influence on their documents or whether there are texts which can be converted to highly structured hypertext only with difficulties. We will investigate these questions in the future.

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Acknowledgements

Peter Purgathofer developed the system DarkStar which was used by students to develop their hypertext documents. Michaela Schuster, Alexander Sogl and Alexander Stadler who are students at our department helped me with the analyses of the documents.